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Responsible Office: Facilities Engineering and Real Property Division

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CHAPTER 6. Facilities Maintenance Management Automation

6.1 Introduction

6.1.1. A requirement exists for facilities maintenance managers throughout NASA to use modern maintenance systems and methods to control their work activities, account for resources they are provided and to monitor and report work execution through the full use of various industry standard metrics and other management indicators. Because of the scope, complexity, and high value of the NASA Center facility inventories, all NASA Centers and most Component Activities use CMMS.

6.1.2. The past decades have seen the application of computer technology to facilities maintenance management expand as systems became more powerful, less costly, and easier to use. NASA Centers have acquired and implemented various CMMS's for use in managing their facilities maintenance program. In many cases, the CMMS shares information interactively with other systems and provides for direct system access by end users.

6.1.3. The Center maintenance data entered in a CMMS is Government property and, as such, must be available for Government use and retention for historical purposes, regardless of who, Government or contractor, is responsible for populating and maintaining the database. Where a contractor operates the CMMS it must be made clear in the contractor's contract that the CMMS maintenance data is Government property and must be turned over to the Government at the end of the contract.

6.2. CMMS Requirements and Usage

Chapter 3, Facilities Maintenance Management, discusses the functions, processes, management concepts, and system of controls recommended for facilities maintenance. Centers should evaluate their maintenance management data requirements and establish their electronic data needs prior to investigating and acquiring a new CMMS or modifying an existing CMMS. Centers should acquire only what is required to accomplish the maintenance organization goals. Of course, once a CMMS is acquired, resources must be dedicated to initially populate the systems (modules) and to continually keep them up to date. The data once entered must be utilized for day-to-day operations and management of the Centers maintenance program to be cost effective. Periodic review of the CMMS data should be made to keep the system abreast of current requirements, deleting unnecessary data entries and adding new ones as required.

6.3. Automated System Interfaces

Facilities maintenance management automation brings the benefits of automation to facilities maintenance functions and processes. Chapter 3, Facilities Maintenance Management, not only discusses functions recommended for

facilities maintenance but also identifies closely related supporting functions and processes. The CMMS should directly support or interface with existing related automated systems such as financial accounting (Asset Management System (AMS) module of the Integrated Financial Management Program (IFMP)), RCM databases and personnel administration systems.

6.4. CMMS Functions

The Center's CMMS must support the major functions discussed in the following paragraphs as they apply to facilities maintenance. Information entered in the functional areas of the CMMS is critical for the day-to-day maintenance operations, management of the Center's maintenance program, for providing data to support the budget process, and for providing historical information critical for use in performance-based contracting. In all of the functional areas, items entered should contain FMS codes and key management information such as criticality codes, condition codes, and downtime associated with an item. Descriptive nomenclature of items must be standardized to permit for the sorting of data. If data is available in separate databases, Centers must provide a link between those and the CMMS in order to collect total maintenance costs, including material and subcontract costs. See Appendix D for typical monitor screen CMMS images used for various functions.

6.4.1. Manage Facilities and Equipment. This function contains the facilities maintenance processes and procedures to be utilized in managing the facilities maintenance workload. In addition to the automation of the administrative processing associated with maintenance management, the major advantage of having a CMMS is the capability to process a large amount of data in order to identify trends that would not be readily apparent by reviewing individual work orders. This processing provides the data needed for benchmarking and for preparing facility condition assessments. A major effort of the CMMS is tying together the various RCM activities. This function also includes facilities planning and processes normally associated with CoF funding and must support those portions of CoF work that are a logical outgrowth of the facilities maintenance effort such as repair, modification, or rehabilitation. The following paragraphs highlight files/modules which are a part of most CMMS's and that are used in managing maintenance programs.

6.4.1.1. Facility/Equipment Inventory. These data files/modules contain a detailed inventory of all facilities and maintainable collateral equipment subject to the facilities maintenance management system (and could include other information if needed for planning, space management, or accounting purposes). For facilities, they include information such as identifier, size, cost, date acquired, category codes, uses, location, users, material condition codes, and other similar information. For equipment, they include nomenclature, manufacturer, part number, cost, serial number, date acquired, size, location, identifiers to major system or use, warranty, specific facilities maintenance requirements, life expectancy, and similar information. Current and reliable data will enhance analysis and budget preparation and may be needed in developing customer charges under NASA's Full Cost Accounting System. Tables 3-2 and 3-3 list representative data elements.

6.4.1.2. Work Input, Control and Scheduling. This data file/module contains information on work requested by customers, work generated internally, and work status as it proceeds from requirement identification to work completion or request disapproval. It includes information on customer, cost estimate, funding, scheduling for execution, and execution status for each work order. This data provides the ability to track facilities projects, requests for facilities maintenance, TC's, and Service Requests. The CMMS may include the capability to receive work requests electronically and accomplish the approval process electronically. Centers should establish a website on the local internet to provide customers with a link to work status reports and any other appropriate maintenance information. A selective combination of electronic and voice interface with customers would probably provide the best support. Appendix C provides sample forms for use in facilities maintenance, including several in CMMS database formats.

6.4.1.3. Reliability Centered Maintenance. This data file/module contains information on facilities and equipment criticality codes, maintenance requirements and schedules. It contains data for equipment and facilities maintenance actions required, predictive testing test points, diagnostic aids, references to or excerpts from maintenance manuals and equipment drawings, schedules, frequency, materials, safety requirements, and related procedures. Linked with the inventory, the combined data files can be used to create PT&I schedules, PM schedules, and work orders or PM task descriptions for use by technicians and mechanics. Criticality codes will be recorded, but updated on an iterative basis as missions and environments change. The CMMS should include the ability to analyze PT&I results, process parameters (including normal baseline temperature, pressure, and flow readings), diagnose the possible causes of abnormal readings, project trends in test results, and schedule facilities maintenance actions or further inspection based on the trends. PT&I Finds and their corrective work should be identified in the CMMS to ensure that priority work is highlighted and tracked. Information and data in the PT&I database should be made available to maintenance engineers, managers and craftspersons through the CMMS. This will ensure that pertinent information needed for maintenance and failure analysis is readily available.

6.4.1.4. Correlation of Maintenance Data. Much benefit can be realized by correlation of various metrics, trends, and data from the PM, PT&I, and other databases. An important function of a CMMS is to automate that correlation as new input is made, with limits that alarm for followup action.

6.4.1.5. Continuous Inspection. This data file/module contains information for the continuous inspection program. (see paragraph 10.5, Continuous Inspection.) It should include facilities maintenance standards, facility condition inspection schedules, and inspection and test procedures. Linked with the inventory, it can be used to create the inspection orders and work sheets used by inspectors. The results of inspections from PT&I's, PM's, operators, Facility Managers, facility users, and Facility Condition Inspections should be entered in the CMMS's history files for use in the FCA.

6.4.1.6. Facility/Equipment History. These data files/module contain summaries of the maintenance histories of the facilities and collateral equipment. They contain summaries of PM, PGM, repairs, TC, rehabilitation, modifications, additions, construction, and other work affecting the configuration or condition of the items. They include completed and canceled work orders. These files also include the current material condition assessment of each item, derived from the continuous inspection program, for use in developing the FCA and the BMAR. By using the CMMS to tie the FCA to the continuous inspection program and specifically to the PT&I database, condition assessments will be more current and equipment condition information, short and long term repair and replacement requirements, and BMAR information are available to the facilities maintenance managers and craftspersons when needed. The maintenance history records can be used to support proactive maintenance techniques such as root-cause failure analysis and reliability engineering.

6.4.2. Provide Utilities Services. Utilities services are essential to a Center in that no operations would be possible without the power, steam, water, and related services they provide. Utilities also represent a major cost of operations. Computer support, both in terms of direct control of system components and analyses to identify losses in efficiency, is vital to energy conservation efforts as well as to effective system maintenance and management for optimal reliability and cost efficiency. The utilities data file/module contains detailed information on utilities consumption, distribution, use, metering, allocation to users, and cost. It could include modeling capability and linkage to utility control systems.

6.4.3. Assist in Formulating and Administering Contracts. Contracts provide the majority of Center facilities support services. In many cases this extends to both recurring facilities maintenance efforts and one-time, specific facilities maintenance projects. Computerized support for contract preparation and administration in support of the Contracting Officer is essential for a well managed facilities maintenance program. This data file/module contains information on contracts supporting the broad spectrum of facilities maintenance management as required by the Contracting Officer, Contracting Officer's Technical Representative (COTR), and Quality Assurance Evaluators (QAE). With other database files, it provides a picture of each contractor's past performance, current loading, and planned work. It could include information on specifications, Government furnished property, quality assurance, payment processing, delivery orders issued, schedules, and related matters. It should cover both contracts for specific facilities maintenance requirements and support services contracts.

6.4.4. Develop Budgets and Perform Cost Analyses. Management is largely the process of allocating and directing resources to accomplish an organization's goals. The functions listed above focus on facilities maintenance work and work methods. The budget and cost analysis functions obtain and track resources. In an environment of competition for limited resources to perform an ever-expanding workload, managers need sophisticated tools and techniques to account for resources, demonstrate efficient use of resources, and prepare persuasive requests for future resource allocations. Computer support to perform in-depth analyses of requirements is essential to meet this end. Refer also to Chapter 2, Resource Management.

6.4.5. Additional Database Functions. The functions discussed above are typically found in NASA Center CMMS's. The functions in the following paragraphs may be included in the CMMS or, in most cases, in separate databases that should be interfaced with the Center's CMMS.

6.4.5.1. Reports and Metrics. This function can be customized for each Center's use as part of the CMMS, provided other key information such as complete cost information and project management data is available. Management should define for all maintenance and operations the management information required from the contractor and civil servant staff so that results/performance-oriented reports and metrics can be developed in the CMMS and tracked. This will ensure that the Government can analyze and evaluate performance and overall maintenance management at that Center.

6.4.5.2. Job Estimating. This data file may contain shop or flat rate guides, estimating tables, work performance (time and motion) standards such as engineered performance standards, labor and material rates, and local cost and time factors in computer-usable form. Sources include commercial services, Government-developed standards, developed Facilities Engineering Job Estimating (FEJE) software, and local experience. After the P&E's define the work elements comprising a job, they can use this data file to estimate task and work order crafts, materials, equipment, tools, time, and costs.

6.4.5.3. Tools/Material. Tools and material data files typically contain the inventory of centrally managed tools and material for use in support of facilities maintenance. The material data file aids in assigning material to work orders, supports the preparation of material requisitions, tracks the receipt of material on order, and documents related information. Also, these data files record accountability data for shop tools and equipment.

6.4.5.4. Environment. This data file contains environmental information, including permits, licenses, the history of violations and citations, potential hazards, environmental compliance and related actions underway, and tracking of work or materials of special environmental interest. For example, it might include data on Polychlorinated Biphenyl (PCB) or asbestos hazards. This file can track the disposal of hazardous waste and hazardous materials or the need for and processing of renewals of discharge permits. Environmental Protection Agency (EPA) rules require detailed records on the management of ozone-depleting substances such as Chlorofluorocarbons (CFC) and hydrochlorofluorocarbons used as refrigerants. These records can be accommodated readily in a computerized database.

6.4.5.5. Space Management/Planning. This data file typically contains user name and user data for each facility, space within the facility, or other asset managed. It may include other information for use in managing the space such as configuration, utilities services, finishes, furnishings, environment, communications, assigned function or task, and accounting information.

6.4.5.6. Facility Graphic Documentation

a. Computer Aided Design and Drafting (CADD), Geographic Information Systems (GIS), and similar systems such as Automated Mapping/Facility Management permits the digitized storage of graphic data on individual facilities such as drawings, photos, and other pictorial information. GIS offers a three-dimensional definition of a facility plus associated databases that together are a powerful facilities engineering tool. For example, a GIS for a street network could include data on underground utilities showing each utility (water, gas, electricity, sewage, storm drainage), parking, traffic volume, pavement condition, and landscaping each in a separate plane. GIS technology fully integrates graphics and text.

b. One GIS system is the Geographic Resources Analysis Support System and its three subsystems, GRID, IMAGERY, and MAP-DEV. GRID analyzes, overlays, and models maps and displays. IMAGERY displays, geo-references, compares, and classifies satellite and aerial photographic imagery. MAP-DEV enables the digitizing and integrating of landscape data generated from hard copy maps, digital elevation files, and other sources for analysis. This technology holds great promise for facilities maintenance applications.

c. Graphic documentation includes references to hard copy drawings, manufacturers shop drawings, and drawings prepared at the Center. Master plan drawings are in this group. Centers may wish to require the submission of all drawings, particularly those for facilities projects, in digitized form. Also, Centers should consider digitizing existing drawings for inclusion in the digital graphics library.

6.4.5.7. Provide Management Support. Management support functions provide the routine internal organizational, administrative, and overhead processes. They include functions related to internal administrative support, document tracking, and personnel accounting performed within the facilities maintenance organization. While the internal management support functions do not interface directly with the facilities maintenance customers, shortcomings in this area directly impact customer support. Dealing with largely administrative matters, management support function productivity can improve through automation. Well-established computer software programs are available for these areas. However, automation of management support and administrative functions is outside the scope of this manual.

6.5. CMMS Peripheral Systems

There are peripheral systems that can be integrated into the CMMS to enhance facilities maintenance operations. These systems can be more efficient, reduce paper work and provide more accurate and complete records in accomplishing maintenance tasks. The selection of a system should be based on the specific maintenance requirements, a cost study and resource availability. The following are some systems that could be considered.

6.5.1. Bar Coding Systems. There are a number of bar coding systems available that can be employed in a Center's facilities maintenance program. The systems vary from the simple identification of an equipment item to sophisticated systems that permit input and downloading of data. Systems are available that permit bar code tags to include such things as the equipment items history and its preventive maintenance program. These tags are updated along with the CMMS as changes take place, thereby providing current status at all times. Systems include software that must be integrated into the Center's CMMS and handheld bar code readers (terminals) with high contrast Liquid Crystal Displays (LCD) and a keyboard system to be used by the technician performing the work. The system may include a beeper subsystem that confirms scanner and keyboard entries, and alerts the operator of error conditions.

6.5.1.1. In one system a technician's day's schedule and tasks instructions are downloaded from the CMMS into the handheld terminal and given to the craft person at start of the shift. When the technician arrives at the work site the equipment bar code tag is scanned. This registers the arrival time and displays the equipment item maintenance functions to be performed. As each work item is completed the technician checks it off using the terminal keyboard. This process continues until all functions have been completed. Any comments are entered and the equipment bar code tag is scanned again to record the completion time. The technician then, proceeds to the next work location and goes through the same scenario. When the days work is completed, the terminal is turned in for down loading

into the CMMS where the equipment files are electronically updated. The next days work schedule and instructions are then downloaded to the terminal for use on the next shift where the process is repeated.

6.5.1.2. Another system utilizes a radio frequency or a cellular digital system to communicate with the Center's CMMS. In this system a technician is given a handheld terminal at the start of the shift. A paper copy of the day's work schedule is provided or the schedule has been downloaded from the CMMS into the terminal. When the technician arrives at the work site the equipment bar code tag is scanned. Using the bar code tag identification the terminal is connected by radio frequency or a cellular digital system to the CMMS where the equipment items history and the day's work functions can be displayed on the terminals LCD as needed. As work is completed the information is entered in the terminal and through the wireless system recorded in the CMMS. With this system the exact status of assigned work is recorded in the CMMS for review at all times.

6.5.2. Handheld Computers. This is another CMMS peripheral system that is available for use in a Center's maintenance program. This is a wireless system where information flows to and from the Center's CMMS. The system could be used to eliminate paper-based work orders; particularly those for TC's, small service requests, and small repair jobs. This would reduce the workload on the work control center and the technicians. With this system the technician receives work orders, work order changes, and updates electronically. The technician reports work start electronically and when work is completed the completion report and comments are provided electronically. Because information flows wireless to and from the CMMS, the work control center sees the exact status of every assigned work order from assignment through work start to completion. At the end of a technician's shift the handheld computer is dropped off for use by the next shift.

6.5.3. Quality Assurance Database. At least one NASA Center has developed software that assists Quality Assurance Evaluators in their monitoring of Performance-based Contracts (Payment Analysis and Support System) developed by Johnson Space Center (JSC)). Typically, QAE's inspect and evaluate the contractor's performance using Surveillance Guides associated with each contract line item number. Summary results are entered into the database by portable data collectors, and the program tabulates all entries and calculates deductions for unsatisfactory work and work not performed. The advantages of using this and similar databases are labor reduction by reducing redundant operations and mathematical calculations, and by maintaining good contract documentation without the paper.

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